A SUPPLEMENT TO THE TREATISE OF *Watch & Clock-work*, CALLED The Artificial Clock-Maker.

Wherein is Contain'd,

1. The Anatomy of a Watch and Clock.
2. Monsieur *Romer*'s Satellite-Instrument: with Observations concerning the Calculation of the Eclipses of *Jupiter*'s *Satellites*, and to find the *Longitude* by them.
3. A nice way to correct *Pendulum Watches*.
4. Mr *Flamsteed*'s Equation Tables.
5. To find a *Meridian-Line* for the Governing of Watches, and other Uses.
6. To make a *Telescope* to keep a Watch by the Fixed Stars.

By *W. D.* M. A.

LONDON,
Printed for *James Knapton*, at the *Crown* in St *Paul*'s Church-yard. 1700.

TO THE READER,

UPon a review of my Book, in order to another Edition, I have thought it neceſſary to add ſome things, and to make ſome ſmall amendments in the body of the Book it ſelf.

And becauſe I think it a piece of juſtice owing to the Buyers of the firſt Edition, that I ſhould endeavour, as much as I can, to make their Edition as compleat as this; therefore, inſtead of inſerting what this Supplement contains into proper places of the Book, I have rather choſen to put it rhapſodically together; and taken care that it be printed ſo, as to be bought by itſelf at a ſmall price.

Alſo

Also I think my self obliged, to be at the pains to collect the most material alterations, and amendments which I have made in my Book, and here to insert them in this Supplement; whereby the Reader may supply with his Pen (if he pleaseth) what is wanting in the first Edition.

The Purchasers both of the first and of this Edition will (we hope) excuse both the Bookseller and me, for reducing this Edition into a lesser Volume, that it may be more portable for the Pocket, and (we hope) both Book and Supplement too, cheaper; at least, not dearer than the first Edition, for the benefit of poor workmen.

Pas-

Paſſages wanting in the firſt Edition.

PAge 5. line 2. after pocket-watches, add [and others] l. 4. after wheels, add [whence it hath its Name] l. penult. dele [ſomtimes.]

P. 7. After l. 11. add [the Train is the Number of Beats which the Watch maketh in an hour, or any other certain time.]

P. 10. l. 24. after *Wheel* 40, add [which runs concentrical, or on the ſame arbor with the ſecond Pinion 5.]

P. 12. l. 3. after has, add [as hath been ſaid.]

P. 15. l. 15. add in the Margin [ſee Sect. 1. §. 3.]

L. 23. In the margin add [See Sect. 1 §. 4]

P. 19. l. 6. add in the Margin [See §. 4.]

P. 20. l. 20. for 2196. r. 20196.

P. 25. l. 2. after *Report* add [fixed on the Great-wheel.]

P. 28. l. 9. add in the Margin [Sect. 1. §. 3.]

P. 30. l. 22. in the Margin add [§. 7]

P. 34. l. 14. after *Report* add [and the Count-wheel.].

P. 35. l. 12. after *Rules*, add[*To find how many ſtrokes the Clock ſtriketh in one turn of the Fuſy, or Barrel.*

L. 19. after *Rule* 2. add [*To find how many days the Clock will go.*]

L. 27. after *Rule* 3. add [*To find the number of turns of the Fuſy or Barrel.*]

P. 36. l. 21. after *Rule* 4. add [*To fix the Pin of Report on the Spindle of the Great-wheel.*]

P. 38. l. 8. after turns, add [of the Fuſy.]

L. 25. after *Then*, add [(if you make the Great-wheel the Pin-wheel.)]

P. 53. l. 9. after *Motions*, add [in Watch-work]

P. 57. l. 17. amend thus [10)59(5.9]

P. 58. l. 26. r. [round by a]

P. 75. l. penult. after *To the*, add[ſquare of the.]

P. 112. l. 20. add [or thus with 16 turns.]

12)72
8)64
8)60
7)56

30

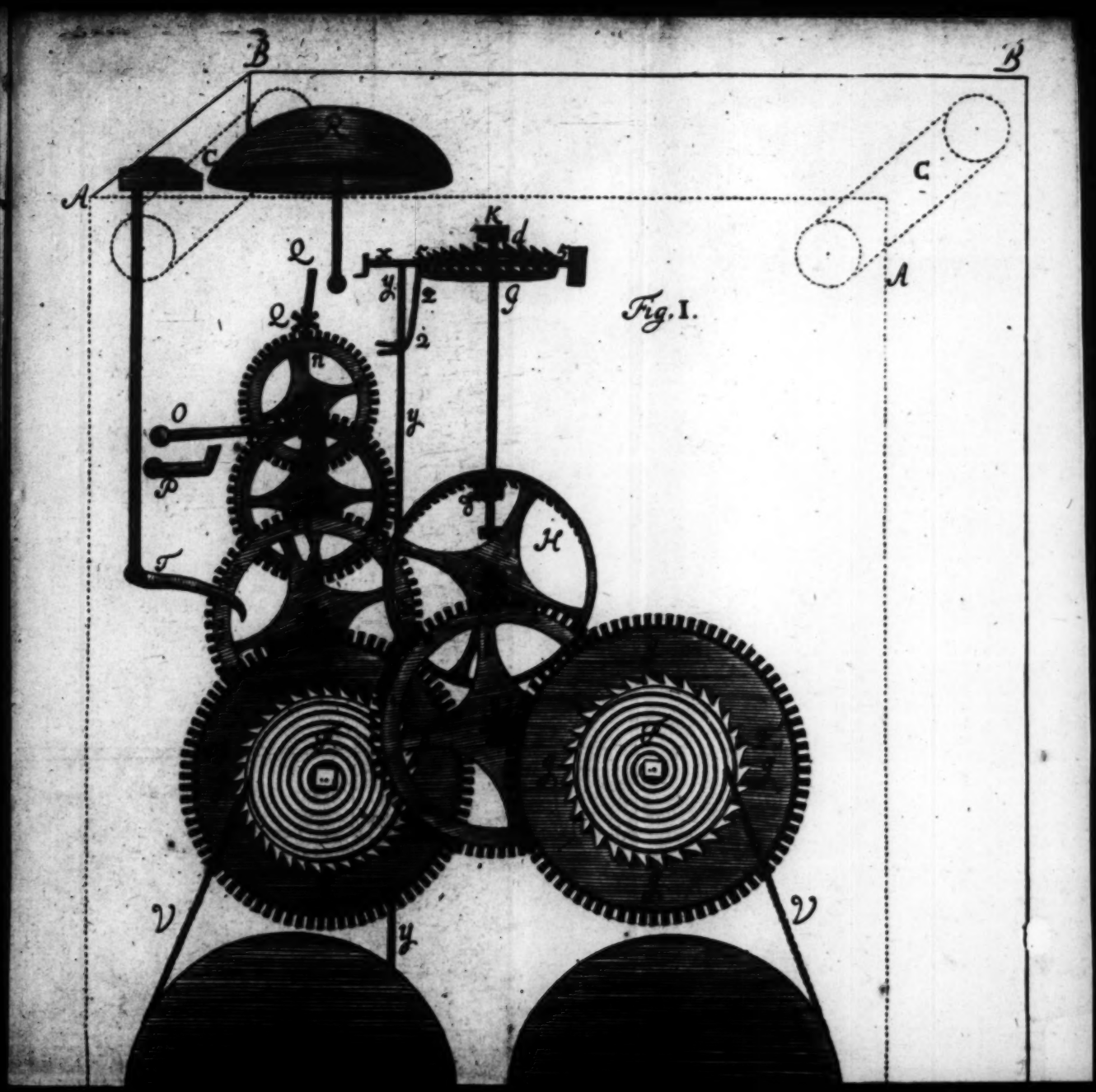


Fig. I.

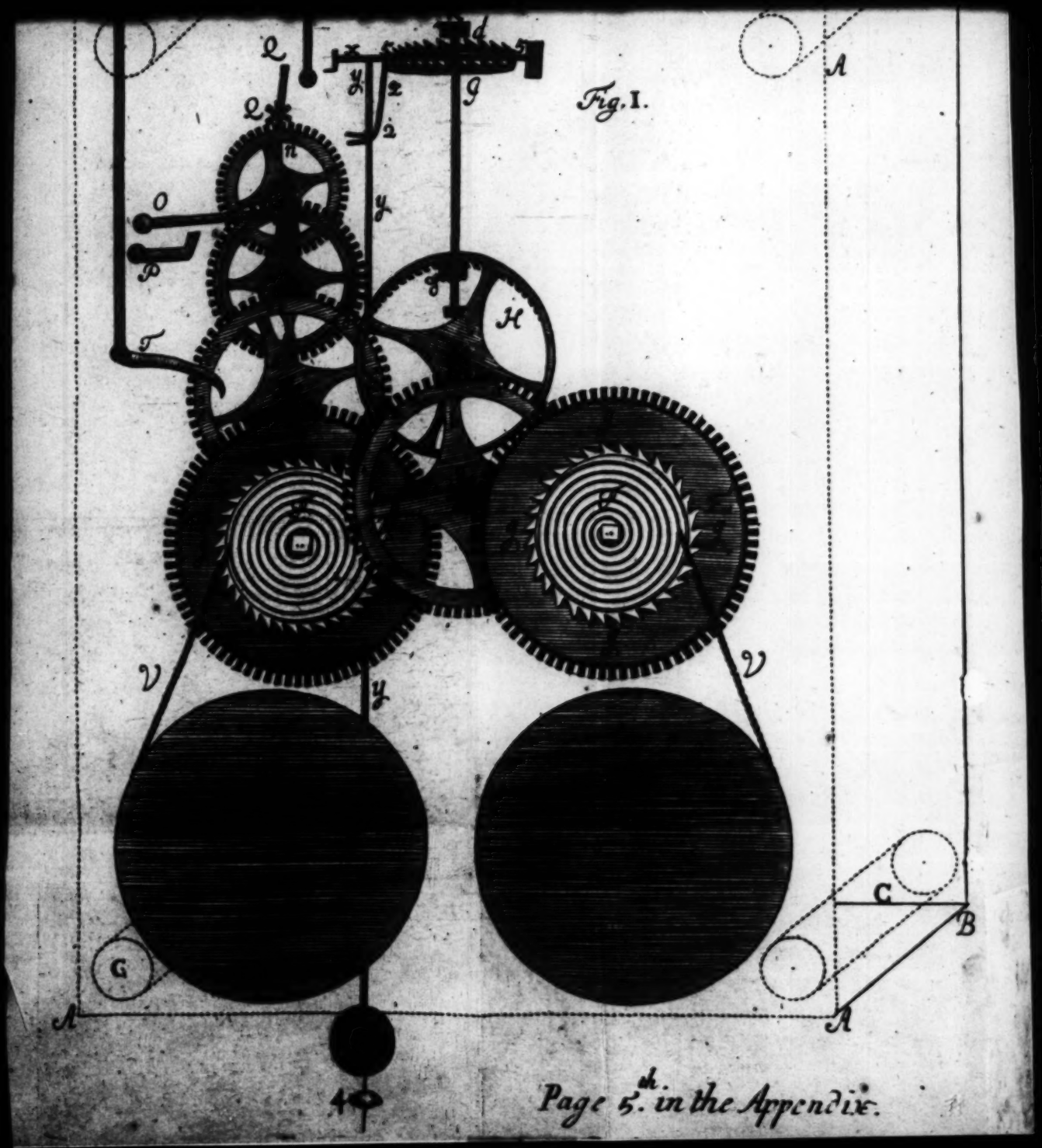


Fig. I.
Page 5th. in the Appendix.

P. 122, to § 3. add [if this Crown-wheel be too large you may use these numbers, *viz.*

12)48
6)48
6(45
6)48 Seconds-hand

15

P. 126. l. 24 after *Sextans*, add [or any other Telescope.]

P. 132. l. 15. after 2. add [by the directions in Chap. 2. Sect. 2. §. 5.]

L. 18, after *If* add [as in the Movements in *ch.* 10.]

I.

An Explication of the Figures.

Fig. 1. Representeth the parts of a *Watch* and *Clock* described in the Book, *Ch.* 1.

The Wheels, *&c.* on the right hand, is the *Watch*-part. They on the left, the *Clock-part.*

A. A. A. A. The upper *Plate* of the *Frame*: which you may imagine to be transparent (as of glass) to admit of a Prospect of the Wheel-work underneath it.

B. B. B. The lower *Plate* of the *Frame.*

C. C. C. C. The *Pillars.*

D. D. The *Spring-Boxes* of the Watch, and Clock-part.

E. E. The *Great-wheel* of each part.

F. F. The *Fuſy* of each part, about which the Chain, or String is wrapped.

g. g. g. g. g. g. g. The *Ratchet* of each part.

a. a. a. The *Hoop*, or *Rim* of the *Second wheel.*

b. b. The *Croſs* thereof.

c. The *Pinion.*

H. The *Contrate-wheel.*

I. The *Crown-wheel.*

d. d. The upper and lower *Pevet* thereof.

K. A piece of Braſs, in which the *Pevet-hole* is, in which the *Pevet* d. playeth.

L. The *Pin-wheel*, with the *Striking-Pins* e. e. e. e. e.

M. The *Detent-wheel.*

N. The *Warning wheel*, or fourth wheel.

O The *Detent.*

P. The *Lifting-piece.*

Q. Q. The *Fan*, and *Flying-Pinion.*

R. The *Bell.*

S. The *Hammer.*

T. The *Hammertail.*

V. V. The Chain, or String of the Watch, and Clock.

x. The *Verge* or *Spindle* of the Ballance, or Pendulum.

y. y. y. The *Rod* of the Pendulum.

z. The *Fork.*

2. The *Flatt.*
3. The *Great-Ball.*
4. The *Corrector* or *Regulator.*
5. 5. The *Pallets.*

II.

Fig. 2.

Rerpreſenteth the *Satellite Inſtrument* of *Monſ. Olaus Romer*, deſcribed in the Book, page 109.

A. B. the upper Plate of the Inſtrument.

C. D. The lower Plate.

K. L. An *Axis*, or *Spindle*, on which four wheels are fixed, and turn round with it, and with the Hand L. once in 7 days. E. F. G. H. are the *Sockets*, or hollow *Arbors* of 4 wheels running concentrically.

The hollow Arbor H. carrieth round the *Firſt-Satellite* p. and belongeth to the Wheel, or Pinion 22, which is driven by the fixed Wheel 87.

The hollow Arbor G. carrieth round the *Second-Satellite* S. and belongeth to the Wheel 32 which is driven by the wheel 63. And the like of the *Arbors* F. and E.

Within all theſe hollow Arbors is another fixed one included, on the top of which is a Ball (I) repreſenting the Planet *Jupiter*: round which the *Satellites* move, repreſented by the litlle Balls p. ſ. t. q.

This

This *Satellite-Inſtrument* may be added to a Watch, by cauſing the Great-wheel or Dial-wheel to drive round the Arbor K. L. once in 7 days. To do which there are ſufficient directions given in the preceding Book.

The uſe of the foregoing Inſtrument.

This *Satellite-Inſtrument* may be of good uſe both at Sea and Land to aſſiſt in finding the longitude by *Jupiter's Satellites*: partly, by giving notice when an approaching Eclipſe is, that we may be ready with a *Teleſcope* to obſerve it; and partly, when any Eclipſe happeneth, to ſhew which *Satellite* it is that is eclipſed, which is difficult to be ſeen in the Heavens: and partly, to ſupply the place of Tables, or Calculation of the *Satellite*-Eclipſes, which it may do for a little while, but it muſt not long be truſted unto.

It may ſeem foreign to my ſubject, to ſhew how the *Longitude* may be found by *Jupiter's Satellites*: but becauſe I would with all my power advance this way (which far tranſcends all others yet known, eſpecially that of the Log-line) therefore I hope the Reader will excuſe this Digreſſion.

The way to find the *Longitude*, by an Eclipſe of any of *Jupiter's* four *Satel-*

lites,

lites is briefly this: knowing by Tables of the Satellite-Eclipſes (ſuppoſe ſuch as Mr *Flamſteed* publiſhed in the *Philoſ. Tranſact.* No 177, and afterwards gave *Parker* leave to publiſh in his *Almanacks*, knowing I ſay) the time when an Eclipſe happeneth in any one part of the World; obſerve by a *Teleſcope*, at what time the ſame Eclipſe happeneth in any other part of the World, the difference of time giveth the difference of *Meridians*. Thus a total Immerſion of the firſt Satellite was obſerved at *Rome*, at 10 h. 07′ 53″ p.m. Which Mr *Flamſteed* notes at 9 h. 15′ 41″. The difference is 52′ 12″; and conſequently, *Rome* is 52′ 12″, or 13 deg. 03′ diſtant from the Meridian of the *Engliſh Obſervatory*, where Mr *Flamſteed* obſerv'd it. *Philoſ. Tranſ. Dec.* 1685. *No.* 117.

I once had thoughts of ſhewing the way to calculate the Eclipſes of *Jupiter's Satellites*, and to make Tables thereof, by the help of my very good Friend Mr *Flamſteed's*, and ſome other obſervations: but conſidering that it would be too great a digreſſion, and eſpecially that Monſieur *Caſſini* hath very ingeniouſly, and well done it for the *Firſt*, I ſhall therefore refer the Reader to his Tables, reduced to the *Meridian* and *Style* of *London*, by that very judicious Mathematician Mr *Halley*, in *Philoſ. Tranſ.* No 214.

The

The Reader, I hope will pardon me, if (before I leave this digreſſion) I obſerve a few things which may be of uſe, not only in the Calculation of the Eclipſes of the 3 outermoſt Satellites, but alſo may contract the labour of Calculation in the firſt.

The firſt thing to be obſerved is *Jupiter*'s place. For if he be on his *Aphelion*, he moves ſloweſt, and conſequently the *Satellites* make their returns to him ſomewhat ſooner, than when he is on his *Mean diſtance* and *Peribelion*. By Mr *Flamſteed*'s firſt Tables the firſt Satellite makes 13 revolutions to *Jupiter*, when he is on his

	days	h.	′	″
Aphelion in ——	23	00	10	30
Mean diſtance ——	23	00	11	48
Peribelion ——	23	00	13	08

The *Second Satellite* makes 16 Revolutions when *Jupiter* is on his

	days	h.	′	″
Aphelion in ——	35	12	55	10
Mean diſtance ——	35	12	59	00
Perehelion ——	35	13	03	15

The *Third Satellite* makes 5 Revolutions when *Jupiter* is on his

	days	h.	′	″
Aphelion in ——	35	19	50	15
Mean diſtance ——	35	19	58	00
Peribelion ——	35	20	06	42

The

The *Fourth*, or furthermoſt *Satellite* makes 5 Revolutions to *Jupiter* in his

	days	h.	′	″
Aphelion in———	82	17	42	55
Mean-diſtance ——	83	18	25	15
Perihelion ———	82	19	12	57

From this account it is eaſy to compute in what time one Revolution of any Satellite is at any time performed: which is the next thing to be obſerved. Thus in *Jupiter*'s *Mean-diſtance* the Revolution of the

	days	h.	′	″
Firſt Satellite is——	1	18	28	36
Second ———	3	13	17	54
Third ———	7	3	59	36
Fourth —— ——	16	18	05	03

The Reader may himſelf, from what hath been ſaid, compute the Periods of the *Satellites* in *Jupiter*'s other places.

From theſe things laid down, it is eaſy from an Eclipſe known, to find the next that will follow. For if you add one, or more Revolutions, you have the Eclipſes following. Thus for example, *July* 12 this year 1700, according to Mr *Flamſteed*'s computation, the firſt Satellite comes out of *Jupiter*'s

	days	h.	′	″
July	12	14	18	00
1 Revol.	1	18	28	36
July	14	8	46	36
4 Revol.	7	1	54	24
July	21	10	41	00

ſhadow.

ſhadow at 14 h. 18′ p. m. (according to Mr *Caſſini*'s at 14 h. 20′ 56″ p m.) conſequently the next Emerſion is on *Jul.* 14th paſt 8 of Clock in the evening. If you add 4 Revolutions, another Emerſion is on *Jul.* 21 at 10 h. 41′ nearly *p. m.* as here is exemplified in the Margin.

The laſt thing I ſhall take notice of concerning the Satellite Eclipſes is their Durations. This varies according as *Jupiter* is nearer unto, or remoter from the 10th degree of ♒ or ♌ (as Mr *Flamſteed* ſays.) About which points are the *Nodes*, or interſections of the plane of the *Satellite Orbit* and *Jupiter*'s, or the *Jovial Ecliptick*. Mr *Caſſini* makes it in 15° of ♒ or ♌, and varies in the length of the Duration of the Eclipſes. But according to Mr *Flamſteed* (the accuracy of whoſe obſervations is not to be diſtruſted) the *greateſt Semiduration* of the

	h	′	″
Firſt Satellite is	1	9	28
Second ——	1	27	38
Third ——	1	48	55
Fourth ——	2	26	19

But as *Jupiter* removeth from his *Nodes*, the Semidurations diminiſh. And when he is gotten 55 degrees from either of his *Nodes*, the *Fourth Satellite* paſſeth clear of the ſhadow, and falleth

leth not into it again, until he comes within 55 degrees of the oppoſite *Node.*

When *Jupiter* is on the Limit, or 90 degrees from his *Nodes*, the *Leaſt Semi-duration* of the Eclipſe of the

	h	′	″
Firſt Satellite is	1	6	49
Second ——	1	18	59
Third ——	1	17	33

From this account of the Duration of the Satellite Eclipſes, we may, having the Immerſion into *Jupiter*'s ſhadow, compute the Emerſion of any Satellite out of his ſhadow: or contrariwiſe, which will be of uſe to ſee both the beginning and end of any Eclipſe, when viſible; I mean, when not hindered by Clouds, day light, or *Jupiter*'s body. Or if by ſome of theſe means we are hindred from ſeeing the one, we may perhaps hereby ſee the other. Thus (for inſtance) this *Auguſt* 6. 1700. the firſt Satellite immerges at 6 h. 44′ *p. m.* which cannot be ſeen, not only by reaſon of day light, but alſo becauſe *Jupiter*'s ſhadow lieth a little to the left of his body; but if you add one whole obſcuration (*viz.* twice 1 ch. 9′ 18″ the emerſion you will find viſible at 9 h 3′ according to Mr *Flamſteed*; at 9 h. 4′ according to Monſieur *Caſſini*'s Tables. Another inſtance will make all

yet

yet more plain, *Oct.* 19. at 9 h. 50′ *p. m.* the 3d Satellite will emerge; from which ſubſtracting one Obſcuration (*viz.* twice 1 h. 48) you will find the immerſion fall at 6 h. 13′ *p.m.* Which may be ſeen, by reaſon that *Jupiter* is at a good diſtance from his Oppoſition to the Sun, ſo that the ſhade lies ſo far on the left hand, as to admit of ſeeing the 3d and 4th Satellite between *Jupiter*'s body and his ſhade.

I might to theſe have added divers other remarks, particularly concerning the Equation of Light, or the time in which Light paſſeth from the Sun to *Jupiter*, which is at laſt ſettled by that ſagacious Obſerver, ſo often before mentioned, Mr *Flamſteed.* But I muſt forbear, fearing that I have already wearied the Readers patience, and ſhall need his pardon for detaining him ſo long on this ſubject, from ſo ſmall an occaſion, as only a Satellite Inſtrument of Watch-work. But I was willing from a ſmall occaſion, rather than not at all, to ſay ſomething to excite the obſervations and enquiries of others concerning this matter, which may be of vaſt uſe in Navigation, making and correcting Maps of Countries, *&c.* Many of thoſe, to whom this matter would be of greateſt uſe, ſcarce ever heard of it, and others (except Monſieur

Caſſini)

Caſſini) have been backward in favouring the World with their obſervations neceſſary to Calculation. It is indeed a novel ſubject, and full of difficulties, on which little hath been written, and concerning which the firſt material obſervations, to be relied on, were *Hodierna*'s and Mr *Rook*'s. Thoſe of the former were publiſhed, but not very accurate: thoſe of the latter were more accurate, but not publiſhed, and neither of them are yet 50 years old. But neither Novelty nor Difficulty ought to diſcourage the curious and the diligent; to excite whom is partly the deſign of this digreſſion.

III.

To correct the motion of Royal Pendulums.

IN Chap. 5. of the preceding Book, I judged it to be a good expedient, to bring a *Pendulum* to vibrate nicely, to add a *Bob* underneath the Pendulum Ball. This I have ſince found to ſucceed ſo much according to expectation, that I think it frivolous to attempt by any of the uſual ways to bring a large ſingle Ball to vibrate to one ſingle Beat, in any conſiderable quantity of Time. But when the Great Ball is brought pretty near its due length, the little Regulating Bob will nicely perform the reſt.

The

The *Great Ball* being of the uſual weight and form, to ſwing Seconds, I would have the *Corrector*, or *Regulating Bob*, to be about 10 ounces *Troy*, to ſcrew up and down beneath the Ball; as is directed in Chap. 5 before.

But after all endeavours of this kind, it muſt be expected, that the Movement will ſtill be expoſed to the influences of the weather, and the alterations cauſed by foulneſs.

For the more eaſy and quick bringing of a Pendulum, that ſhould ſwing Seconds to its true length, I have compoſed the following Table, which ſheweth the alterations which will be made in 24 hours by ſcrewing up, or letting down the great Ball. If therefore the Ball runs upon a Rule divided into inches, and tenths of an inch, 'tis eaſy to ſee how much, or how little the Ball needeth to be altered.

Pendul. length		Variation of Vibrat.	
in.	ten	Min.	Sec.
38	0	22	33
38	1	20	38
38	2	18	43
38	3	16	48
38	4	14	55
38	5	13	2
38	6	11	9
38	7	9	16
38	8	7	25
38	9	5	32
39	0	3	42
39	1	1	51
39	2	00	00
39	3	1	50
39	4	3	40
39	5	5	29
39	6	7	19
39	7	9	7
39	8	10	57
39	9	12	42
40	0	14	29

Faster. Slower.

This Table will need little explication. If your Ball ſhould be at 39 inches 2 tenths, it would ſwing Seconds. If you alter it to 39 inches, 1 tenth, it would go 1′ 51″ faſter: if to 39 inches 3 tenths, it would go 1′ 51″ ſlower. And ſo of the reſt of the Table.

Of

IV.

Of the Equation of Natural Days.

BY reaſon that the Sun's motion in his Orbit is not equal, and that although he moved equal arches of the *Ecliptick* in equal times, yet he would come to the Meridian with unequal arches of the *Equator*, by whoſe equal Revolutions the *Equal Time* is meaſured; hence (I ſay) it will happen, that altho a Clock ſhould go ſo exactly, as at the years end to agree with the Sun, yet it will vary from the times ſhewed by the exacteſt Sun-Dials. The quantity of which Variations may be ſeen in the following Tables for every day in the year. For which Tables I am greatly obliged to that moſt accurate Aſtronomer Mr *Flamſteed* ſo often mentioned.

Theſe Tables need but little explication. If you would keep your Watch to the *Middle* or *Equal motion* of the Sun, it muſt go ſo many minutes and ſeconds faſter or ſlower than the Sun-Dial, as the Tables ſhew. But if you would keep your Watch to go by the Sun-Dial, you may conclude it goes well, if it loſeth or gaineth every day, ſo many Seconds as you will find in the Table. Thus (for example) *Jan.* 1. in *Leap year*, the Watch ought to be 8 min. 47 Sec. faſter than the

Mr *Flamsteed's* Tables of *Æquat*

The *Bissextile*, or *Lea*

	Jan.		*Febr.*		*Marc.*		*April.*		*May.*		*June.*		*July.*	
	M.	S.	M.	S	M	S	M	S	M	S	M	S	M	S
1	8	47	14	49	10	00	0	41	4	10	0	59	4	47
2	9	10	14	48	9	43	0	24	4	11	0	47	4	55
3	9	32	14	46	9	26	0	8	4	12	0	34	5	2
4	9	54	14	43	9	9	0	7	4	13	0	22	5	9
5	10	15	14	40	8	51	0	22	4	12	0	10	5	15
6	10	36	14	36	8	33	0	37	4	11	0	03	5	20
7	10	55	14	31	8	15	0	52	4	10	0	16	5	25
8	11	14	14	26	7	57	1	6	4	8	0	29	5	30
9	11	32	14	20	7	39	1	19	4	5	0	42	5	34
10	11	49	14	13	7	20	1	31	4	2	0	55	5	37
11	12	5	14	5	7	1	1	44	3	59	1	7	5	40
12	12	22	13	57	6	43	1	57	3	54	1	20	5	43
13	12	37	13	48	6	24	2	9	3	50	1	33	5	45
14	12	51	13	39	6	05	2	19	3	45	1	46	5	45
15	13	5	13	29	5	46	2	30	3	39	1	59	5	46
16	13	18	13	18	5	27	2	41	3	33	2	11	5	46
17	13	30	13	7	5	9	2	51	3	26	2	23	5	45
18	13	41	12	56	4	50	3	0	3	19	2	35	5	44
19	13	51	12	44	4	31	3	8	3	11	2	47	5	42
20	14	0	12	32	4	13	3	16	3	3	2	59	5	40
21	14	9	12	18	3	54	3	24	2	54	3	10	5	37
22	14	17	12	5	3	36	3	32	2	46	3	22	5	33
23	14	24	11	51	3	17	3	39	2	37	3	33	5	29
24	14	30	11	36	2	59	3	45	2	27	3	44	5	25
25	14	35	11	21	2	40	3	50	2	17	3	54	5	19
26	14	39	11	5	2	22	3	54	2	6	4	4	5	13
27	14	43	10	50	2	5	3	58	1	56	4	13	5	07
28	14	46	10	34	1	47	4	2	1	45	4	22	5	0
29	14	47	10	17	1	30	4	5	1	34	4	31	4	52
30	14	49			1	13	4	8	1	22	4	39	4	44
31	14	49			0	57			1	11			4	35

Watch too fast.
Watch too slow.
Watch too fast.

Leap-year.

July.		Aug.		Sept.		Octob.		Nov.		Dec.	
	S	M	S	M	S	M	S	M	S	M	S
	47	4	26	3	58	13	22	15	49	5	28
	55	4	16	4	19	13	36	15	10	4	59
	2	4	5	4	39	13	49	15	01	4	too 31
	9	3	54	5	00	14	2	14	50	4	2
	15	3	43	5	20	14	14	14	38	3	33
	20	3	31	5	41	14	26	14	26	3	3
	25	3	18	6	1	14	37	14	13	2	slow. 33
	30	3	5	6	22	14	47	14	00	2	3
	34	2	52	6	43	14	57	13	45	1	33
	37	2	38	7	3	15	6	13	30	1	4
	40	2	24	7	24	15	15	13	13	0	34
	43	2	9	7	44	15	24	12	56	0	4
	45	1	too 54	8	4	15	30	12	38	0	fast. 26
	45	1	38	8	24	15	36	12	19	0	56
	46	1	22	8	43	15	42	12	00	1	26
	46	1	5	9	3	15	47	11	40	1	56
	45	0	48	9	23	15	51	11	20	2	25
	44	0	31	9	too 42	15	too 54	10	too 59	2	Watch. 34
	42	0	* 13	10	:	15	57	10	37	3	too 23
	40	0	* 5	10	21	15	59	10	14	3	52
	37	0	22	10	3	16	00	9	50	4	21
	33	0	too 40	10	slow. 57	16	slow. 01	9	slow. 26	4	too 40
	29	0	too 59	11	15	16	00	9	2	5	too 16
	25	1	19	11	32	15	59	8	37	5	43
	19	1	39	11	4	15	57	8	11	6	11
	13	1	58	12	6	15	54	7	45	6	37
	07	2	17	12	22	15	50	7	19	7	3
	0	2	slow. 37	12	37	15	46	6	52	7	fast. 29
	52	2	57	12	54	15	40	6	24	7	54
	44	3	18	13	8	15	34	5	57	8	18
	35	3	38			15	27			8	41

	Jan.		*Febr.*		*Marc.*		*April.*		*May*		*June.*		J
	M	S	M	S	M	S	M	S	M	S	M	S	M
1	9	4	14	48	10	4	0	45	4	10	1	2	4
2	9	26	14	46	9	47	0	28	4	1	0	50	4
3	9	48	14	44	9	30	0	12	4	12	0	37	5
4	10	10	14	41	9	13	0	3	4	13	0	25	5
5	10	31	14	37	8	55	0	18	4	12	0	13	5
6	10	50	14	32	8	37	0	33	4	11	0	0	5
7	11	9	14	27	8	19	0	48	4	10	0	13	5
8	11	27	14	21	8	1	1	2	4	8	0	26	5
9	11	45	14	15	7	43	1	16	4	6	0	39	5
10	12	2	14	7	7	25	1	28	4	3	0	52	5
11	12	18	13	59	7	6	1	41	4	0	1	4	5
12	12	Watch. 34	13	Watch 50	6	Watch 47	1	Watch 54	3	Watch 56	1	Watch 17	5
13	12	47	13	41	6	28	2	6	3	51	1	30	5
14	13	2	13	31	6	10	2	19	3	46	1	43	5
15	13	15	13	21	5	51	2	2	3	40	1	56	5
16	13	27	13	10	5	32	2	38	3	4	2	8	5
17	13	38	12	59	5	14	2	48	3	8	2	20	5
18	13	too 48	12	too 47	4	too 55	2	too 57	3	too 21	2	too 32	5
19	13	58	12	35	4	36	3	6	3	13	2	44	5
20	14	7	12	22	4	17	3	14	3	5	2	56	5
21	14	15	12	8	3	58	3	22	2	56	3	7	5
22	14	fast. 22	11	54	3	fast. 42	3	slow. 30	2	48	3	19	5
23	14	28	11	fast. 40	3	22	3	37	2	slow. 39	3	fast. 30	5
24	14	3	11	24	3	3	3	4	2	28	3	41	5
25	14	3	11		2	45	3	4	2	19	3	51	5
26	14	4	10	54	2	26	3	53	2	9	4	1	5
27	14	4	10	38	2	8	3	57	1	59	4	11	5
28	14	47	10	21	1	51	4	1	1	48	4	20	5
29	14	48			1	34	4	4	1	37	4	29	4
30	14	49			1	17	4	7	1	25	4	37	4
31	14	49			1	1			1	14			4

Place these Tables in the Appen

	July		Aug.		Sept.		Octob.		Nov.		Dec.	
	S	M	S	M	S	M	S	M	S	M	S	M
2	4	45	4	2	3	53	13	18	15	21	5	35
50	4	58	4	18	4	14	13	32	15	13	5	6
37	5	0	4	2	4	34	13	46	15	3	4	38
25	5	7	3	55	4	55	13	59	14	53	4	9
13	5	13	3	46	5	15	14	11	14	41	3	40
0	5	18	3	34	5	36	14	23	13	29	3	10
13	5	24	3	21	5	56	14	34	14	17	2	40
26	5	29	3	8	6	17	14	44	14	3	2	10
39	5	33	2	54	6	38	14	54	13	49	1	40
52	5	36	2	41	6	58	15	4	13	34	1	11
4	5	39	2	27	7	19	15	13	13	17	0	41
17	5	42	2	13	7	39	15	22	13	0	0	11
30	5	44	1	58	7	59	15	28	12	43	0	19
43	5	45	1	42	8	19	15	34	12	24	0	49
56	5	46	1	26	8	38	15	40	12	5	1	19
8	5	46	1	9	8	58	15	45	11	45	1	49
20	5	45	0	51	9	18	15	50	11	25	2	18
32	5	44	0	35	9	37	15	53	11	4	2	47
44	5	42	0	17	9	57	15	56	10	42	3	16
56	5	40	0	1	10	16	15	58	10	20	3	45
7	5	38	0	18	10	34	15	59	9	56	4	14
19	5	34	0	36	10	52	16	1	9	32	4	42
30	5	30	0	55	11	10	16	0	9	8	5	9
41	5	26	1	14	11	28	15	59	8	48	5	36
51	5	20	1	34	11	45	15	57	8	17	6	4
1	5	14	1	53	12	2	15	55	7	51	6	30
11	5	8	2	12	12	18	15	51	7	25	6	57
20	5	2	2	32	12	33	15	47	6	59	7	33
29	4	54	2	52	12	49	15	41	6	31	7	48
37	4	46	3	13	13	4	15	35	6	3	8	32
	4	37	3	33			15	20			8	35

pendix between Page 18 and 19.

	Jan.		Feb.		Marc		April		May		June.		July.		Aug.	
	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S
1	8	59	14	48	10		9	49	4	9	11		4	43	4	
2	9	21	14	47	9	5	0	32	4	11	0	53	4	51	4	
3	9	43	14	45	9	34	0	16	4	12	0	40	4	58	4	
4	10	5	14	42	9	17	0	1	4	13	0	28	5	5	4	
5	10	26	14	38	8	5	0	14	4	12	0	16	5	11	3	
6	10	45	14	33	8	41	0	29	4	11	0	3	5	17	3	
7	11	4	14	28	8	24	0	44	4	10	0	10	5	23	3	
8	11	23	14	23	8		0	58	4	8	0	23	5	28	3	
9	11	40	14	14	7	47	1	12	4	6	0	36	5	32	2	
10	11	57	14	9	7	25	1	26	4	4	0	49	5	35	2	
11	12	14	14	1	7	10	1	38	4	1	1	2	5	38	2	
12	12	30	13	52	6	52	1	51	3	57	1	14	5	41	2	
13	12	44	13	43	6	33	2	3	3	52	1	27	5	43	2	
14	12	58	13	34	6	15	2	14	3	47	1	40	5	45	1	
15	13	12	13	24	5	56	2	24	3	41	1	53	5	46	1	
16	13	24	13	13	5	37	2	35	3	35	2	5	5	46	1	
17	13	35	13	2	5	18	2	46	3	29	12	17	5	45	0	
18	13	46	12	50	5	0	2	56	3	23	2	29	5	44	0	
19	13	56	12	37	4	41	3	4	3	15	2	41	5	42	0	
20	14	5	12	25	4	22	3	12	3	7	2	53	5	40	0	
21	14	13	12	12	4	3	3	20	2	58	3	4	5	38	0	
22	14	20	11	57	3	44	3	28	2	50	3	16	5	35	0	
23	14	27	11	43	3	26	3	35	2	41	3	27	5	31	0	
24	14	32	11	28	3	8	3	42	2	31	3	38	5	27	1	
25	14	37	11	13	2	49	3	47	2	21	3	48	5	22	1	
26	14	41	10	58	2	31	3	52	2	11	3	59	5	16	1	
27	14	44	10	42	2	13	3	56	2	1	4	9	5	10	2	
28	14	47	10	25	1	55	4	0	1	51	4	18	5	3	2	
29	14	48			1	38	4	3	1	40	4	27	4	56	2	
30	14	49			1	22	4	6	1	28	4	35	4	48	3	
31	14	49			1	5			1	17			4	39	3	

Watch too fast. slow.

Aug.		Sept.		Octob.		Nov.		Dec.	
M	S	M	S	M	S	M	S	M	S
4	30	3	48	13	14	15	23	5	42
4	20	4	9	13	28	15	15	5	13
4	10	4	29	13	42	15	5	4	too 45
4	0	4	50	13	56	14	55	4	16
3	49	5	10	14	8	14	44	3	47
3	37	5	31	14	20	14	32	3	17
3	24	5	Watch 51	14	Watch 31	14	Watch 20	2	Watch 47
3	11	6	12	14	41	14	6	2	17
2	58	6	33	14	51	13	52	1	47
2	44	6	53	15	1	13	38	1	18
2	30	7	14	15	11	13	21	0	48
2	16	7	34	15	20	13	4	0	18
2	too 2	7	too 54	15	too 26	12	too 47	0	too 12
1	46	8	14	15	32	12	28	0	42
1	30	8	33	15	38	12	9	1	12
1	13	8	53	15	44	11	50	1	42
0	56	9	13	15	49	11	30	2	11
0	39	9	flow. 32	15	flow. 52	11	flow. 9	2	flow. 40
0	fall. 21	9	52	15	55	10	47	3	Watch 9
0	3	10	11	15	57	10	25	3	38
0	14	10	30	15	59	10	2	4	7
0	31	10	48	16	1	9	38	4	35
0	too 50	11	6	16	0	9	14	5	too 2
1	9	11	24	15	59	8	49	5	29
1	29	11	41	15	57	8	23	5	57
1	49	11	58	15	55	7	57	6	23
2	7	12	14	15	52	7	31	6	50
2	flow. 27	12	29	15	48	7	5	7	fall. 16
2	47	12	45	15	43	6	38	7	41
3	8	13	0	15	37	6	10	8	6
3	28			15	31			8	29

M	*Jan.*		*Feb.*		*Marc.*		*April.*		*May*		*June.*		*July.*		*A*
D	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M
1	8	53	14	49	10	12	0	53	4	9	1	8	4	41	4
2	9	15	14	47	9	54	0	36	4	10	0	56	4	49	4
3	9	37	14	45	9	38	0	20	4	12	0	43	4	57	4
4	9	59	14	42	9	21	0	4	4	13	0	31	5	4	4
5	10	20	14	39	9	4	0	11	4	12	0	19	5	10	3
6	10	41	14	34	8	46	0	26	4	12	0	6	5	13	3
7	11	00	14	29	8	28	0	41	4	11	0	7	5	22	3
8	11	18	14	24	8	10	0	55	4	9	0	20	5	27	3
9	11	36	14	18	7	52	1	9	4	7	0	33	5	31	3
10	11	54	14	11	7	34	1	22	4	4	0	46	5	35	2
11	12	10	14	3	7	15	1	35	4	1	0	58	5	38	2
12	11	26	13	54	6	56	1	48	3	58	1	11	5	41	2
13	12	41	13	45	6	38	2	0	3	53	1	24	5	43	2
14	12	55	13	36	6	19	2	11	3	48	1	7	5	45	1
15	13	9	13	26	6	0	2	22	3	43	1	30	5	46	1
16	13	21	13	15	5	41	2	33	3	37	2	2	5	46	1
17	13	33	13	4	5	23	2	43	3	31	2	14	5	45	1
18	13	43	12	53	5	4	2	52	3	24	2	26	5	44	0
19	13	53	12	41	4	45	3	1	3	17	2	38	5	43	0
20	14	03	12	28	4	26	3	10	3	9	2	50	5	41	0
21	14	11	12	15	4	7	3	18	3	0	3	2	5	39	0
22	14	18	12	1	3	49	3	26	2	52	3	13	5	36	0
23	14	25	11	47	3	31	3	33	2	43	3	25	5	32	0
24	14	31	11	32	3	18	3	40	2	34	3	36	5	28	1
25	14	36	11	16	2	54	3	46	2	2	3		5	23	1
26	14	40	11	1	2	31	3	51	2	14	3	57	5	17	1
27	14	43	10	46	2	17	3	55	2	4	4	7	5	11	2
28	14	46	10	30	2	0	3	59	1	53	4	16	5	5	2
29	14	47			1	42	4	3	1	42	4	25	4	58	2
30	14	48			1	25	4	6	1	31	4	33	4	50	3
31	14	49			1	9			1	19			4	41	3

Watch too fast. too slow. fast too slow. fast too slow.

Aug.		Sep.		Octob.		Nov.		Dec.	
M	S	M	S	M	S	M	S	M	S
1	4	32	3	43	13	11	15	25	5	49
0	4	23	4	4	13	25	15	17	5	20
0	4	13	4	24	13	39	15	8	4	52
0	4	2	4	45	13	53	14	58	4	23
0	3	51	5	5	14	8	14	49	3	54
0	3	40	5	26	14	17	14	35	3	25
0	3	27	5	46	14	28	14	23	2	55
0	3	14	6	7	14	39	14	10	2	28
0	3	01	6	28	14	49	13	50	1	55
0	2	48	6	48	14	59	13	41	1	25
0	2	34	7	9	15	9	13	25	0	56
0	2	20	7	29	15	18	13	8	0	26
too	2	5	too	7	49	too	15	25	too	12
0	1	50	8	9	15	31	12	33	0	34
0	1	34	8	29	15	37	12	14	1	4
0	1	17	8	48	15	43	11	55	1	34
0	1	0	9	8	15	48	11	35	2	4
fast	0	43	slow.	9	28	15	52	11	14	2	33
0	0	26	9	47	15	55	10	53	3	2
0	0	9	10	7	15	57	10	31	3	31
0	0	9	10	25	15	59	10	8	4	0
0	0	27	10	43	16	0	9	44	4	28
too	0	46	11	1	16	1	9	20	too	4
0	1	5	11	19	16	0	8	55	5	23
0	1	24	11	37	15	58	8	30	5	50
0	1	44	11	54	15	56	8	4	6	17
1	2	3	12	10	15	53	7	38	6	44
slow	2	22	12	26	15	49	7	12	fast	7	10
0	2	42	12	41	15	44	6	45	7	36
0	3	3	12	57	15	38	6	17	8	0
1	3	23			15	32			8	24

the Sun Dial: on *Jan.* 2. it ought to be 9′ 10″, *&c.* If you would know on the ſame days, whether your Watch goes well, when kept to go by the Sun-dyal if ſet on *Jan.* 1. it hath gained on *Jan.* 2. as much as 8′ 47″ wanteth of 9′-10″. *viz.* 23″ you may conclude your Watch goes well. Otherwiſe you muſt ſcrew up, or let down the *Ball* or *Corrector*, until it loſeth, or gaineth according to the Equation Tables.

The Tables will ſerve for many years, being mede for *Biſſextile*, and the 3 years following. By an Almanack therefore, or any other way, knowing the Year, you may find what Table you are to uſe all that year.

By reaſon of the Refractions, or ſome error in the Sun-Dial, it may be convenient to compare, or ſet your Watch at ſome certain hour of the day. Noon is a good time for it, if you have a nice *Meridian-line*, or any way to ſee when the Sun is exactly South, becauſe the time of the Day is not at all then varied by the Refractions, in Dials that caſt a ſhade.

V.

To find a Meridian-Line.

It may happen that we may be at a Place, where there is no Sun-Dial, or not one to be relied upon; or indeed where

where we have a good one, it may be of great uſe to us to have a *Meridian-Line.* For the finding of which there are divers ways, but I ſhall ſhew only two.

The firſt is, draw one or more Circles on ſome plain, as on the bottom of a Southern Window. (Or you may make the center on the Southern edge of the Window, and draw only half circles.) Hang up a Thread and Plumbet exactly over, or in the center of the Circles. By a Bead or two ſliding up and down the Thread, mark out exactly the points of the Circles, touched by the Shade of the Beads in ſome of the Morning Hours (the longer before Noon the better.) In the afternoon when the ſame ſhade of the Beads toucheth the circles, mark that point, or points alſo. A line drawn thro the Center, and in the middle, between theſe two points in the Circle, is the Meridian-line, or near ſo.

If you can't hang up a Plumbet, a Pin ſet exactly upright will do the matter.

Another, and better way, is by the *Pole ſtar*, when it is exactly upon the Meridian. Or if but near ſo, the error will not be great.

You may find the time when the Pole-ſtar comes to the Meridian, by Subſtracting the Suns Right Aſcention from

the

right Aſcention of the Pole-ſtar, and turning the remainder into hours, minutes and ſeconds, allowing to every degree four minutes of time, whereby you will have the Apparent time, when the Pole-ſtar comes on the Meridian above the Pole. I ſcarce need to obſerve, that the time when it comes under the Pole is 12 hours diſtant.

You may ſhorten your labour by uſing Tables of the Sun's right aſcention in Time, which you may find in Sir *J. Moor's Mathem. Compendium.*

Note, If the *Sun's* R. Aſcention exceeds the *Pole-ſtar's* R. A. you muſt add 24 hours to the Pole-ſtar's R. A. & then ſubſtract. The right aſcention of the Pole-Star is determined by Mr *Flamſteed* 0^h 33'. 44'' of time in the year 1690, and the increaſe of its R. Aſcention 1'. 16'' of time in 10 years. Therefore this preſent Year 1700 its true R. Aſcention is 0^h 35'. 00'' of time.

If the unlearned Reader ſhould think this way difficult, he may ſee when the *Pole-Star* comes near the Meridian, by hanging up a Line and Plumbet, and obſerving when the firſt Star in the *Great-Bear's* tail, next her Rump, comes under the Line on one ſide of the Pole, or when the Plumb-line interſects the Star in *Caſſiopeia's* Knee on the other ſide of the Pole.

When

When the *Pole-ſtar* is found to be on the Meridian, if you hang up two ſtrings with Plumbets, between the *Pole-Star* and your eye, this will be a *Meridian-line*, to ſee when the Sun comes to the Meridian. Or you may do it with a Crevis between two boards, or plates of Metal, almoſt touching one another. Or (which is a better way) with a pair of Sights, ſuch as Surveyors uſe (but much longer) with a Crevis in one Sight next the eye; and a large aperture in the other with a fine Cars-gut ſtring down the middle. Theſe ſhould be counter-changed, ſo as to look either at the Pole-ſtar by night; or the other way at the Sun by day.

But much the beſt way which I have yet thought of, and which is exceedingly nice, is with the inſtrument, Fig. 3. which is thus made. At each end of a board, or rather ſmall flat Iron-bar (A. B) fix two upright ſights: one with a very ſmall Hole (a. b.) to look through to the Sun; the other (c. d) with a larger hole, to look at the Pole-ſtar. Not far from the Sights, on the ſame bar, fix two arms (C.D, C.D) to bend off, ſo as to be out of the way of the Sights, when you look through them. On the top of theſe arms, place a ſmall rod of Iron or Wood, to turn with a joynt at D. which rod is to bear

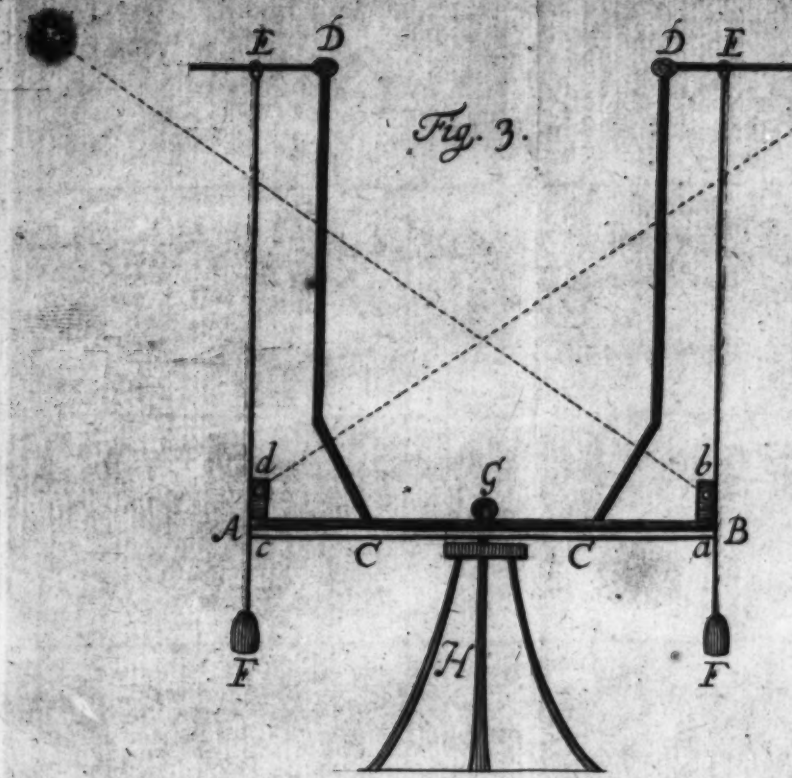


Fig. 3.

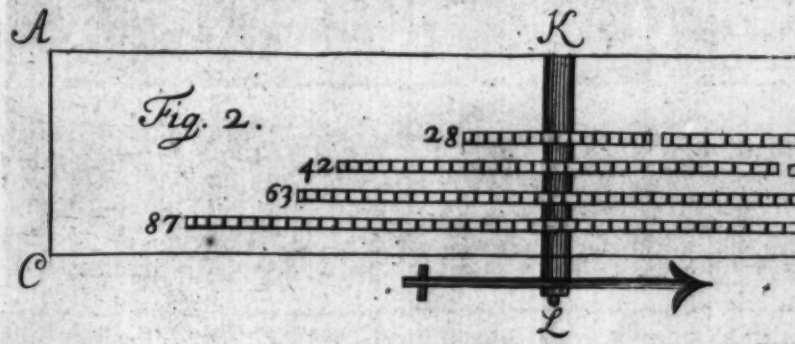
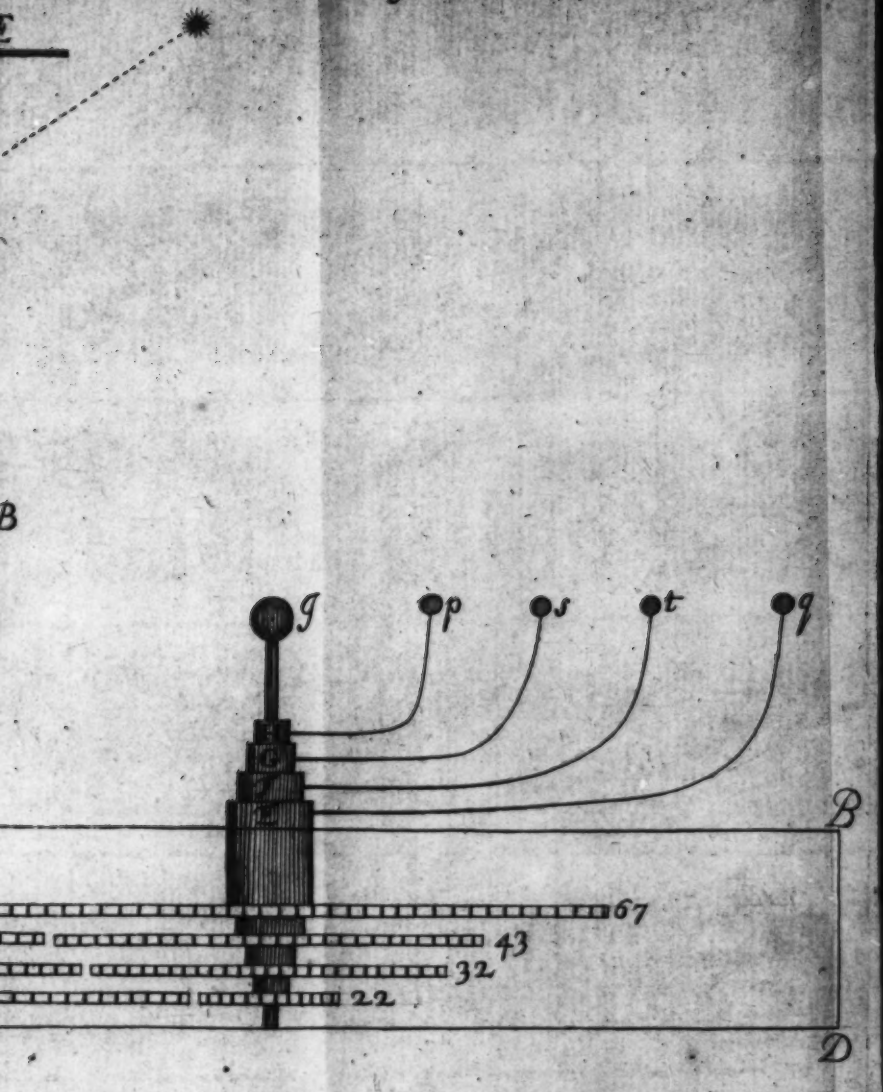


Fig. 2.


E
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B
67
43
32
22
D

bear the Plumb-lines (E. F.) and to turn backward and forward, ſo as to bring the Plumb-lines to the Sights at any time. Place this inſtrument on a Pedeſtal (G. H.) to turn round on it ſtiffly.

Your inſtrument being thus prepar'd, plant it in ſome convenient place, where you may ſee the Pole ſtar, by night, and the Sun by day. When the Pole-ſtar is on the Meridian, look thro the Sight with the bigger Hole, and turn the whole inſtrument about until you ſee the oppoſite Plumb line interſect the Pole-ſtar. Take care at the ſame time, that the Plumb-lines hang ſo as to interſect the Sights. Your inſtrument, thus plac'd, ſtandeth nicely in the Meridian, ſo as to ſee when either Sun, Moon, or Stars come on the Meridian.

When you look by night, 'tis neceſſary that a Candle ſhould ſhine on the Plumb-line, that you may ſee it.

If you look at the Sun, you muſt guard your eye againſt the Sun-beams with a coloured Glaſs, or one blackened with the ſmoak of a Candle.

I had almoſt forgotten, to ſay that it matters not much what length the bottom piece, A. B. is of (but the longer the better) provided that the Plumb-lines are high enough to ſee the Pole-

ſtar, and the Sun in the Summer Solſtice, or any time of the Year. If the bottom piece be 2 feet long, the Plumb-lines had need to be near 4 feet.

This inſtrument is very ſerviceable to ſeveral purpoſes: particularly 1. To ſee the *Southing* of the Sun, or Moon: which you may do with great exactneſs. You may ſee nicely when the very edge of the Sun or Moon toucheth the Meridian, and whilſt all their body is paſſing it.

2. You may ſee what Stars are, at any time, on the Meridian, either Northward or Southward; and ſo find the hour of the night.

3. You may with all exactneſs continue your Meridian-line for many Miles, if you pleaſe, by looking thro either Sight, and ſeeing what objects the Plumb-lines interſect.

4. If you would be ſtill more nice, you may apply a *Teleſcope* to this *Meridian Inſtrument*, by placing, for the Eye-glaſs, a Convex glaſs, of a convenient *Focus* at a due diſtance between the Plumb-line and either Sight, ſo as thro the Sight to ſee the Plumb-line thro the Convex glaſs (or Eye-glaſs.) And at a convenient diſtance from the Inſtrument place another Convex-glaſs for the Object-glaſs.

5. I

5. If I am not much mistaken this *Meridian-Instrument* may as well (and being made Telescopulous) much better serve the design of trying whether the Meridian differeth or not; which some have experimented with more trouble and expence than this instrument comes to.

6. This Instrument is very easily brought to the Meridian. For whether it standsupright, aside, or any other way, still the Plumb-lines may be brought easily to their due place.

7. This instrument is prepared with little cost or trouble; it may be carried from place to place; or imitated whereever there is occasion to correct either Sun Dial or Watch.

A Table, shewing the Time when the Pole-Star *is on the Meridian.*

M.	*January.*		*February.*		*March.*		*April.*		*August.*		*Septemb.*		*October.*		*Novemb.*		*Decemb.*	
D.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.	Hour.	Min.
5	4	45	2	40	0	51	10	55	2	54	1	1	11	8	9	6	6	57
10	4	23	2	21	0	33	10	37	2	34	0	42	10	49	8	46	6	35
15	4	3	2	2	0	15	10	18	2	17	0	24	10	30	8	25	6	13
20	3	42	1	43	11	54	9	59	1	58	0	6	10	11	8	3	5	51
25	3	22	1	24	11	35	9	40	1	40	11	47	9	50	7	41	5	29
30	3	00			11	17	9	21	1	22	11	29	9	30	7	20	5	7

Morning. Morning. Morning. Evening. Evening. Morn. Morn. Evening. Evening.

This Table is intended for the unskilful Reader, to whom it may be of uſe for ſome years. But it will in time run out, by reaſon of the increaſe of the Pole-ſtar's R. Aſcention, Leap year, *&c.*

The Hour and Minute when the Pole-ſtar comes on the Meridian is ſhewn every fifth day. But in *May*, *June*, and *July* it cannot be ſeen, when it is on the Meridian, by reaſon of Daylight.

The Table will be ſufficiently explained by an Example or two. *Jan.* 5. The Pole-ſtar comes to the Meridian at 45 minutes after 4 of clock in the morning; at which time you may ſet your *Meridian-Inſtrument*. So you may do the ſame, on *Mar.* 20th at 54, after 11 of clock at night, at which time alſo the Pole-ſtar is on the Meridian.

VI.

To make a Teleſcope for the Government of Watches.

In *chap.* 11. I mentioned a *Teleſcope* for the governing a Watch by the *Fixed Stars*. And becauſe it is the niceſt way I have mentioned (by reaſon you may ſee a Star paſs at one Beat of a Pendulum) therefore I ſhall here deſcribe the way to make ſuch a *Teleſcope*, as is needful for this purpoſe.

Prep-

Prepare your ſelf with two Convex glaſſes: the one (for the Object-glaſs) to have its *Focus*, or *Cons* about 6 feet, or according to the length you intend your Teleſcope: the other glaſs (for the eye-glaſs) about 2 or 3 inches. Lodge theſe Glaſſes in a Tube of thin boards, paſt-board, or what you think fit. Between the *Object* and *Eye-glaſs*, at the focal diſtance of the *Eye-glaſs* (*viz.* about 3 inches) place two fine Hairs or Threads acroſs, ſo as to be ſeen clearly when you look thro the *Eye-glaſs*. Let there be an aperture near theſe croſs hairs, that the light of a Candle may ſhine on them, in the night, when you look at a Star. It is convenient that the *Eye-glaſs* and Croſs-Hairs or Threads, ſhould be lodged in a ſhort leſſer Tube by themſelves, ſo as to go into, and ſlide backward and forward, in the end of the larger Tube; whereby you may ſet the *Eye-glaſs* and *Croſs-Strings* nearer unto, or farther off from the *Object-Glaſs*. Alſo there muſt be a conical Socket of Wood before the *Eye-glaſs*, ſuch as is uſual in all Teleſcopes, to look thro: but its perforation muſt be very ſmall, ſo as only to give you leave to ſee the Star through it.

Your *Teleſcope* being thus prepared, you muſt plant it for obſervation, as is directed in the foregoing Book.

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